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(54) Abstract Title
Radar heartbeat monitor

(57) A device for monitoring the heartbeat of a living body comprises a radar (1) which directs a beam of microwave radiation (e.g. within the frequency band 1-25 GHz) towards a body whose heartbeat is to be monitored. A phase-shift signal is derived representative of the phase-shift between the transmitted signal and the reflected signal. A controllable filter (3) (which may be a digital filter) filters the phase-shift signal to pass a frequency spectrum anticipated to contain signals corresponding to the heartbeat monitored. The output of the filter is passed to a spectral analysis unit (5) which provides a signal to control circuit (4) which controls the filter. An output signal representative of a heartbeat being monitored may be passed to an alarm (7) which may be associated with additional sensor means (8). The device may incorporate an antenna located in a support for the body whose heartbeat is to be monitored.

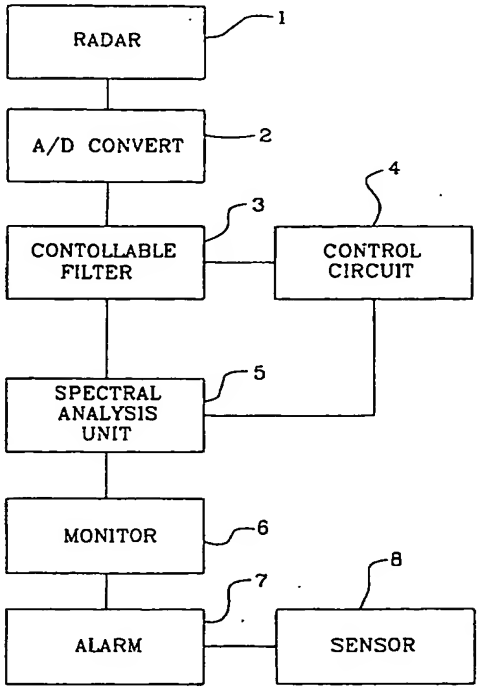

FIG 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

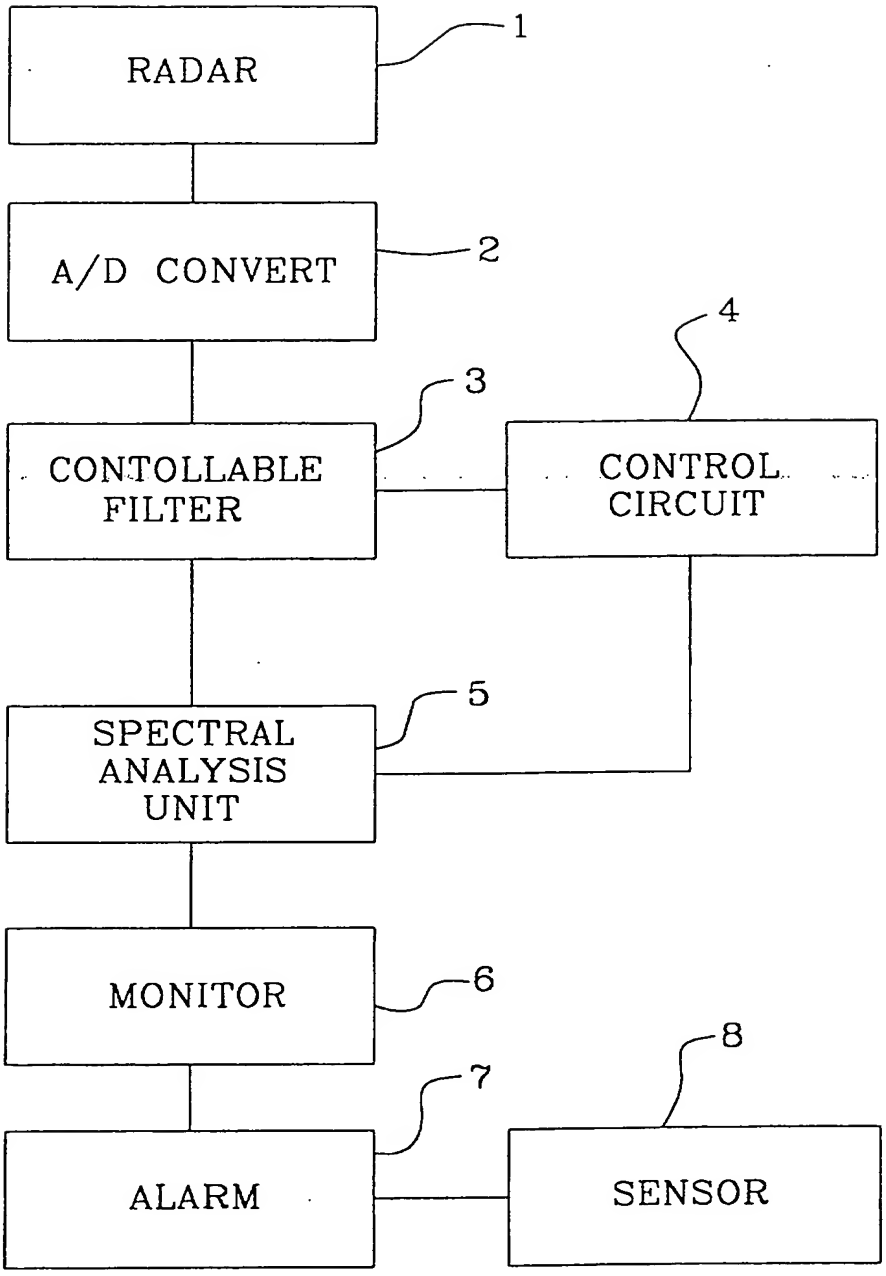
RADAR
1
A/D CONVERT
2
CONTOLLABLE FILTER
3
CONTROL CIRCUIT
4
SPECTRAL ANALYSIS UNIT
5
MONITOR
6
ALARM
7
SENSOR
8

FIG 1

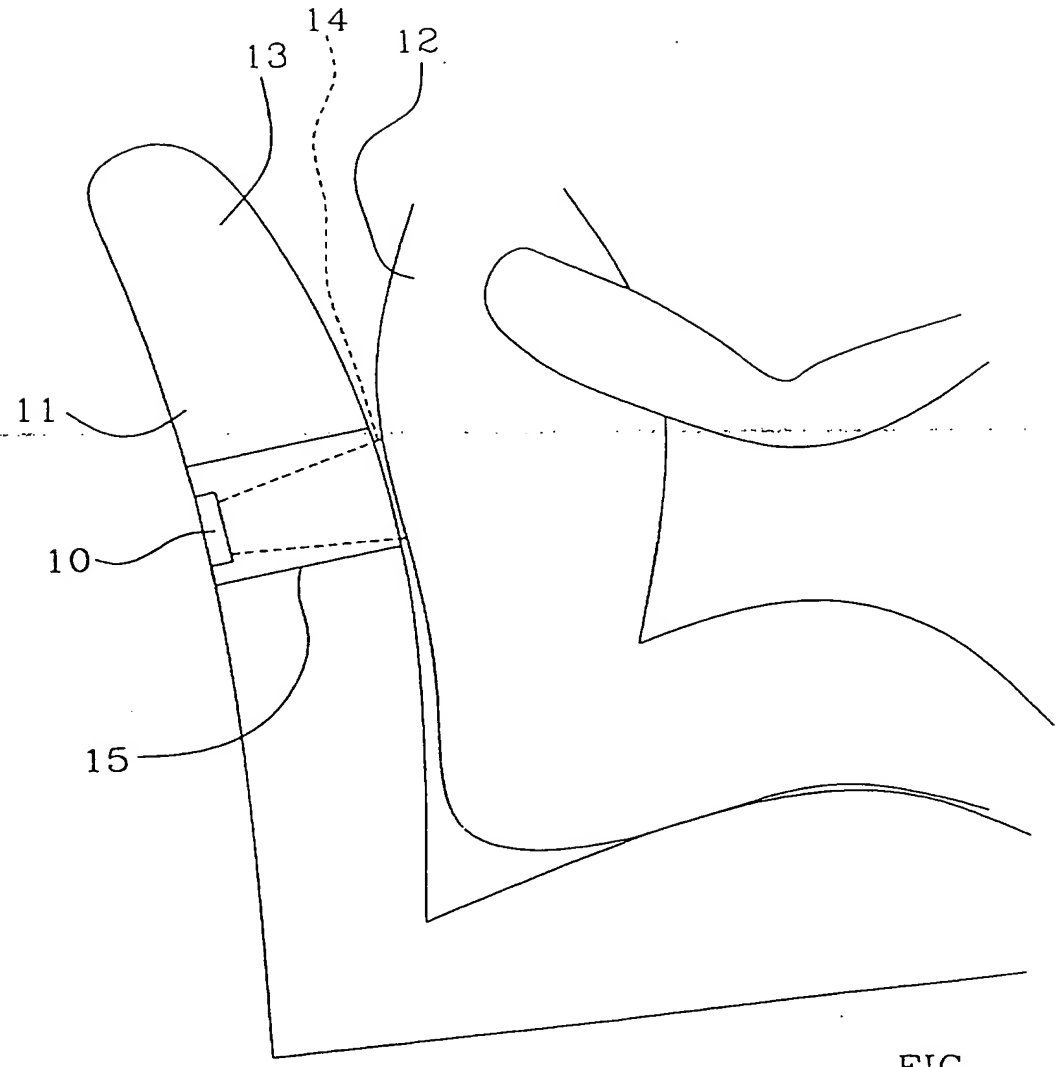

FIG 2

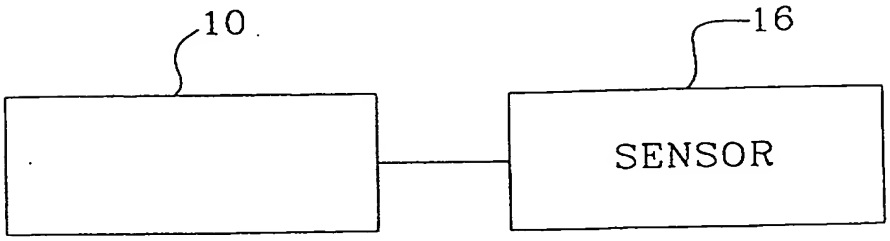

FIG 3

DESCRIPTION OF INVENTION

"IMPROVEMENTS IN OR RELATING TO A DEVICE FOR MONITORING A HEARTBEAT"

THE PRESENT INVENTION relates to a device for monitoring a heartbeat.

There are many situations where it is desirable to be able to monitor a heartbeat.

Medical patients, both in hospital and at other locations, frequently require to have their heartbeat monitored. Additionally, it is desirable to be able to monitor the heartbeat of the driver of a vehicle or controller of machinery in order to determine whether the driver of the vehicle, or controller of the machinery is in a state where it is likely that the driver or controller may fall asleep.

The present invention seeks to provide an improved heartbeat monitoring apparatus.

According to one aspect of this invention there is provided a device for monitoring a heartbeat comprising a radar adapted to detect a beam of microwave radiation towards a living body whose heartbeat is to be monitored,

and to derive a phase-shift signal representative of the phase-shift between a transmitted signal and a reflected signal, a controllable filter to filter the phase-shift signal and to pass a frequency spectrum anticipated to contain signals corresponding to the heartbeat to be monitored, an output of the filter being passed to a spectral analysis unit to conduct a spectral analysis to isolate the signals representative of the heartbeat, the spectral analysis unit being adapted to control the filter by reducing the pass-band width of the filter and selecting the pass-band frequency range so that the filter passes the signals corresponding to the heartbeat, the arrangement providing an output signal representative of the heartbeat being monitored.

Preferably the phase-shift signal is passed through analogue-to-digital converter, and the filter is a digital filter.

Conveniently means to monitor the output signal representative of the heartbeat and to generate an alarm signal if the monitored signal meets predetermined criteria.

Advantageously the alarm is associated with additional sensor means adapted to sense a parameter indicative of the approach of sleep to the person whose heartbeat is being monitored.

Conveniently the radar incorporates an antenna, the antenna being located in part of a support for the body whose heartbeat is to be monitored to direct said beam of microwave radiation towards the body supported by the support.

According to another aspect of this invention there is provided a device for monitoring a heartbeat of a living body, said device comprising a radar, the

radar incorporating an antenna adapted to direct a lobe of radiation towards the person whose heartbeat is to be monitored, the antenna of the radar being mounted within a support for the body whose heartbeat is to be monitored.

Conveniently the support for a body is a seat.

Preferably the antenna is mounted in the back of the seat.

Alternatively the antenna is mounted in the squab of the seat.

In a further embodiment the support comprises a mattress or part of a bed.

Conveniently the antenna is mounted in a padded part of the support, the antenna being located within a radiation guide formed within the padded part of the support leading from the antenna to the surface of the padded part of the support being a surface which, in use, will be in contact or adjacent to part of the body whose heartbeat is to be monitored.

Preferably the radiation guide is formed from a generally tubular formation of a material impervious to microwave energy.

Conveniently said radiation guide is constituted by a fabric impregnated with a ferrite material.

Advantageously the device may incorporate a telemetry unit.

Preferably the radar operates at a power of between 1 and 10 milli-watts.

Conveniently the radar operates within the frequency band 1-25 gHz.

Preferably the radar operates at 2.45, 5.8 or 24 gHz.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a block diagram of a preferred monitoring device in accordance with the invention,

FIGURE 2 is a sectional view of an apparatus in accordance with the invention, and

FIGURE 3 is a block diagram of a further embodiment of the invention.

Referring initially to Figure 1 of the accompanying drawings, a heartbeat monitoring unit comprises a radar apparatus 1 which incorporates an integral antenna adapted to transmit a lobe of electromagnetic radiation, such as microwave radiation towards a living body whose heartbeat is to be monitored. The body may be a human body. The radiation, or at least part of the radiation, will be reflected by the body. The phase shift of the reflected signal as received by the radar relative to the signal transmitted by the radar is measured. Any change in phase shift is representative of a change of distance between the surface of the body and the radar. Part of the surface of the body moves with every heartbeat, and it is this movement that is to be detected and monitored.

The radar will transmit a lobe of microwave energy within the general frequency band of 1-25 gHz. For reasons of potential accuracy, the frequency band of 10-25 gHz is preferred, with the frequency of 24 gHz being especially preferred, since this frequency will it is believed, be available for general use. Other frequencies available for general use are 2.45 gHz and 5.8 gHz, and thus these frequencies may find commercial favour for that reason. The preferred radar is a low power radar operating at a power of 1-10 milli-watts.

The radar may be a continuous wave radar, or a pulsed radar.

The radar is adapted to measure the phase shift between the transmitted signal and the received signal reflected from the person towards which the lobe of microwave radiation is detected. This signal will contain a component relating to the movement of the surface of the body caused by their heartbeat, and of course, any "background" that might be encountered by the lobe of radiation.

In the described embodiment of the invention, the output signal from the radar is passed to an analogue-to-digital converter 2 which converts the original analogue signal into a digital signal. The digital signal is passed to a controllable filter 3 which is associated with a control circuit 4 adapted to control the filter 3.

The filter 3 is adapted initially to be a relatively broad band filter, passing signals and having a frequency within a range equivalent to that of the range of normal heartbeat frequencies, for example a range of 50-120 beats per minute.

The output of the filter 3 is passed to a spectral analysis circuit unit 5. The spectral analysis unit operates to identify a signal passed by the filter 3 having a regular repeating frequency representative of a heartbeat. When the lobe of radiation is directed towards a person, such a signal will be present in the signal present at the output of the filter 3, since at least parts of the body of the person at whom the lobe of radiation is directed will move towards and away from the transmitting antenna of the radar with a frequency equal to the pulse rate.

The spectral analysis unit is connected to the control arrangement 4, and controls the filter 3 so that the filter 3 selectively passes a frequency band that incorporates the measured heartbeat frequency. The arrangement is such that should the heartbeat rate of the body at whom the lobe microwave energy is directed by the radar 1 should either rise or fall, the spectral analysis unit 5 will "follow" the rise or fall in heartbeat and will, through the control circuit 4, adjust the filter so that the filter 3 always passes the current heartbeat frequency of the body.

The output of the spectral analysis unit, in this embodiment, is passed to a monitor 6. The monitor 6 is adapted to monitor the heartbeat and to compare the measured heartbeat with heartbeat patterns that are typical of persons entering a state in which they are likely to fall asleep. It is well known that the rate of the heartbeat of a person who is about to fall asleep frequently falls, and should the monitor 6 detect such a situation, the monitor circuit 6 passes an output to an alarm circuit 7.

It is to be appreciated that the arrangement as described above may be mounted in a motor vehicle, or may be mounted in conjunction with machinery that is controlled by an operator, with the lobe of microwave energy being

directed towards the driver of the vehicle, or the operator of the machine. In such an embodiment, the alarm circuit 7 may be an audible alarm or a visual alarm, or may be an arrangement which terminates operation of the machine.

In an arrangement of this type it is preferred that at least one additional sensor 8 is provided adapted to sense a parameter that may indicate that the vehicle driver, or machine operator, is approaching a state in which the driver or operator may fall asleep. Such a sensor may comprise, for example, a sensor adapted to sense whether the eyes of the driver/operator are open or closed, or a sensor adapted to sense whether the vehicle is being driven in an appropriate manner, or whether the machine is being operated in an appropriate manner.

However, it is to be understood that in an alternative embodiment the heartbeat monitoring unit may be used for medical purposes. The monitor circuit 6, in such an embodiment, will be adapted to respond to a predetermined heartbeat pattern, as may be appropriate.

Figure 2 illustrates a complete radar arrangement 10, which may be an arrangement incorporating the items described in Figure 1 in conjunction with the reference numerals 1 to 6, which is mounted in position in the seat-back 11 of a seat adapted to support a person 12 who is a driver of a vehicle, or the operator of a machine.

The radar unit 10 is located towards the rear of the back-rest 11 of the seat, and is spaced from the back Of the person 12 by padding 13. The radar is adapted to transmit a lobe of radiation identified in phantom, 14. In order to constrain the lobe of radiation to have a desired pattern, part of the seat-back 11, that forms the support of the torso of the person 12 occupying the seat, is configured to form a radiation impervious guide that directs the lobe 14 to

occupy a desired position. The guide may have a generally tubular form surrounding the radar 10, and being directed towards the front part of the seat-back 11. The tubular guide 15 may be formed by a generally tubular structure surrounding the radar 10, and being directed towards the front part of the seat-back 11. The tubular guide 15 may be formed of a material that is impervious to microwave radiation. Thus the tubular guide 15 may be formed from a fabric soaked in a ferrite material and permitted to dry, which may be embedded within the padding of the seat or, alternatively, may be formed by an appropriate metalisation provided within the seat.

The region within the tubular radiation impervious guide will be filled with padding so that the radar and the radiation impervious guide do not lead to any discomfort for the occupant of the seat.

It can be seen, however, that the use of the guide 15 directs the lobe 14 of radiation from the radar 10 towards the back of the person 12 occupying the seat, thus minimising the risk of the lobe encountering any external "noise". The lobe 14 of radiation may be thus be constrained so that it is not a divergent lobe.

Whilst Figure 2 illustrates a radar device incorporated in the back of a seat which is acting as a support for a person, it is to be appreciated that a radar device of the type generally described above may be mounted using the same technique within a mattress of a bed that forms a support for a person.

It is to be appreciated that in appropriate circumstances, as shown in Figure 3, a radar device 10, as mounted in a vehicle seat, or as mounted in a mattress, may be connected to a telemetry apparatus 16 adapted to transmit signals representative of the monitored heart rate or an alarm signal to a remote

location. Thus, the present invention contemplates, within its scope, a mattress intended for use by a patient in a domestic situation, the mattress incorporating the described radar device, and being associated with a telemetry unit so that details of the heart beat of the patient or an alarm signal may be transmitted to a remote location for appropriate processing at that remote location.

CLAIMS:

1. A device for monitoring a heartbeat comprising a radar adapted to detect a beam of microwave radiation towards a living body whose heartbeat is to be monitored, and to derive a phase-shift signal representative of the phase-shift between a transmitted signal and a reflected signal, a controllable filter to filter the phase-shift signal and to pass a frequency spectrum anticipated to contain signals corresponding to the heartbeat to be monitored, an output of the filter being passed to a spectral analysis unit to conduct a spectral analysis to isolate the signals representative of the heartbeat, the spectral analysis unit being adapted to control the filter by reducing the pass-band width of the filter and selecting the pass-band frequency range so that the filter passes the signals corresponding to the heartbeat, the arrangement providing an output signal representative of the heartbeat being monitored.

2. A device according to Claim 1 wherein the phase-shift signal is passed through analogue-to-digital converter, and the filter is a digital filter.

3. A device according to Claim 1 or 2 wherein the device further includes means to monitor the output signal representative of the heartbeat and to generate an alarm signal if the monitored signal meets predetermined criteria.

4. A device according to Claim 3 wherein the alarm is associated with additional sensor means adapted to sense a parameter indicative of the approach of sleep to the person whose heartbeat is being monitored.

5. A device according to any one of the preceding Claims wherein the radar incorporates an antenna, the antenna being located in part of a support for the body whose heartbeat is to be monitored to direct said beam of microwave radiation towards the body supported by the support.

6. A device for monitoring a heartbeat of a living body, said device comprising a radar, the radar incorporating an antenna adapted to direct a lobe of radiation towards the person whose heartbeat is to be monitored, the antenna of the radar being mounted within a support for the body whose heartbeat is to be monitored.

7. A device according to Claim 5 or 6 wherein the support for a body is a seat.

8. A device according to Claim 7 wherein the antenna is mounted in the back of the seat.

9. A device according to Claim 7 wherein the antenna is mounted in the squab of the seat.

10. A device according to Claim 6 wherein the support comprises a mattress or part of a bed.

11. A device according to any one of Claims 5 to 10 wherein the antenna is mounted in a padded part of the support, the antenna being located within a radiation guide formed within the padded part of the support leading from the antenna to the surface of the padded part of the support being a surface which, in use, will be in contact or adjacent to part of the body whose heartbeat is to be monitored.

12. A device according to Claim 11 wherein the radiation guide is formed from a generally tubular formation of a material impervious to microwave energy.

13. A device according to Claim 11 or 12 wherein said radiation guide is constituted by a fabric impregnated with a ferrite material.

14. A device according to any one of the preceding Claims incorporating a telemetry unit.

15. A device according to any one of the preceding Claims wherein the radar operates at a power of between 1 and 10 milli-watts.

16. A device according to any one of the preceding Claims wherein the radar operates within the frequency band 1-25 gHz.

17. A device according to Claim 16 wherein the radar operates at 2.45, 5.8 or 24 gHz.

18. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 1 of the accompanying drawings.

19. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 2 of the accompanying drawings.

20. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 3 of the accompanying drawings.

21. Any novel feature or combination of features disclosed herein.

Amendments to the claims have been filed as follows

1. A device for monitoring a heartbeat comprising a radar adapted to direct a beam of microwave radiation towards a living body whose heartbeat is to be monitored, and to derive a phase-shift signal representative of the phase-shift between a transmitted signal and a reflected signal, a controllable filter to filter the phase-shift signal and to pass a frequency spectrum anticipated to contain signals corresponding to the heartbeat to be monitored, an output of the filter being passed to a spectral analysis unit to conduct a spectral analysis to isolate the signals representative of the heartbeat, the spectral analysis unit being adapted to control the filter by reducing the pass-band width of the filter and selecting the pass-band frequency range so that the filter passes the signals corresponding to the heartbeat, the arrangement providing an output signal representative of the heartbeat being monitored.

2. A device according to Claim 1 wherein the phase-shift signal is passed through analogue-to-digital converter, and the filter is a digital filter.

3. A device according to Claim 1 or 2 wherein the device further includes means to monitor the output signal representative of the heartbeat and to generate an alarm signal if the monitored signal meets predetermined criteria.

4. A device according to Claim 3 wherein the alarm is associated with additional sensor means adapted to sense a parameter indicative of the approach of sleep to the person whose heartbeat is being monitored.

5. A device according to any one of the preceding Claims wherein the radar incorporates an antenna, the antenna being located in part of a support for the body whose heartbeat is to be monitored to direct said beam of microwave radiation towards the body supported by the support.

6. A device for monitoring a heartbeat of a living body, said device comprising a radar, the radar incorporating an antenna adapted to direct a lobe of radiation towards the person whose heartbeat is to be monitored, the antenna of the radar being mounted within a support for the body whose heartbeat is to be monitored.

7. A device according to Claim 5 or 6 wherein the support for a body is a seat.

8. A device according to Claim 7 wherein the antenna is mounted in the back of the seat.

9. A device according to Claim 7 wherein the antenna is mounted in the squab of the seat.

10. A device according to Claim 6 wherein the support comprises a mattress or part of a bed.

11. A device according to any one of Claims 5 to 10 wherein the antenna is mounted in a padded part of the support, the antenna being located within a radiation guide formed within the padded part of the support leading from the antenna to the surface of the padded part of the support being a surface which, in use, will be in contact or adjacent to part of the body whose heartbeat is to be monitored.

12. A device according to Claim 11 wherein the radiation guide is formed from a generally tubular formation of a material impervious to microwave energy.

13. A device according to Claim 11 or 12 wherein said radiation guide is constituted by a fabric impregnated with a ferrite material.

14. A device according to any one of the preceding Claims incorporating a telemetry unit.

15. A device according to any one of the preceding Claims wherein the radar operates at a power of between 1 and 10 milli-watts.

16. A device according to any one of the preceding Claims wherein the radar operates within the frequency band 1-25 gHz.

17. A device according to Claim 16 wherein the radar operates at 2.45, 5.8 or 24 gHz.

18. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 1 of the accompanying drawings.

19. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 2 of the accompanying drawings.

20. A heartbeat monitoring device substantially as herein described with reference to and as shown in Figure 3 of the accompanying drawings.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 9908914.6
Claims searched: 1

Examiner: C R Brain
Date of search: 18 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4D (DRPG, DRPK)

Int Cl (Ed.6): A61B 5/02; G01S 13/88

Other: Online: WPI, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US4991585	(Mawhinney) Whole document.	At least claim 1.
X	US4513748	(Nowogrodzki et al) Whole document.	At least claim 1.
X	US4085740	(Allen, Jr) Whole document.	At least claim 1.
X	Radar 97, IEE conference Pub No. 449, P150-154.	(Grenekar) Whole document.	At least claim 1.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.